IODP Proposal Cover Sheet

Weddell Sea History

848 - Full

Title	Late Neogene to Quaternary ice-sheet and sea-level history of the Weddell Sea, Antarctica
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Abstract

Drilling Neogene sites from the Weddell Sea will address critical questions about stability of the Antarctic Ice Sheet (AIS). With one of the world's two largest ice shelves, the Filchner-Rnne Ice Shelf, the Weddell Sea is a major source of Antarctic Bottom Water (AABW) formation, which influences the Atlantic Meridional Overturning Circulation. Ice-sheet dynamics in the Weddell Sea sector of the East AIS (EAIS) are susceptible to far-field changes in sea level. Most icebergs from the EAIS merge in the Weddell Sea before they exit Antarctica through the Scotia Sea, providing a unique location to study AIS dynamics. Despite these paramount scientific issues that have, over the last two decades, identified the Weddell Sea as a key area to study past changes in the AIS, there has been no deep scientific drilling for high-resolution reconstruction of Late Neogene to Quaternary variability in AIS dynamics and AABW formation.

Our scientific objectives will achieve the first complete Late Neogene to Quaternary reconstruction for the Weddell Sea, and relate to IODP Science Plan 2013-2023 Challenge 1 (elevated CO2) and Challenge 2 (ice sheets and sea level). We will address overarching questions on changing AIS dynamics, interhemispheric phasing of ice-sheet and climate events, and AABW formation. Specifically, we will address the following questions. (1) Can we date reflector W5 in contourite sequences and does it constitute the transition into full glacial conditions in the Weddell Sea? (2) Did the EAIS contribute to the sea-level highstand during the Lower Pliocene. (3) Was the formation of levee ridges north of Crary Fan associated with a sea-level drop initiated through intensification of Northern Hemisphere glaciation during the Late Pliocene? (4) Did the sediment cyclicity change during the Mid-Pleistocene Transition? (5) Can we decipher ice-sheet and sea-level dynamics on glacial-to-interglacial time scales? (6) Can we detect far-field sea-level effects and rates of sea-level rise from Iceberg Alley? (7) Can we relate varve thickness variations to external (solar) or internal (ocean-atmosphere) variability on decadal-to-centennial time scales?

We propose to drill levee ridges and contourite drifts northeast of Riiser-Larson Ice Shelf that contain high-resolution sections necessary to reconstruct EAIS dynamics through the Late Neogene and Quaternary. One test site should obtain a complete Cenozoic record from Polarstern Plateau. Contingency plans involve drilling farther north, outside the sea-ice zone, and in the Scotia Sea. High-resolution seismic data are available for all proposed sites, and sediment cores exist for most sites.

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Scientific Objectives

Scientific objectives focus on Miocene-to-Pleistocene reconstruction of AIS dynamics, sea-level development, and changes in ocean-atmosphere circulation in the Weddell Sea:
- What is the age of reflector W5 and does it document establishment of full glacial conditions in the Weddell Sea Embayment during the Miocene?
- Did the EAIS contribute to the sea-level highstand during the Mid-Pliocene warm period? Were sea-ice coverage, biogenic productivity, and sea surface temperatures different at that time?
- Is the formation of the southern and middle ridges north of Crary Fan related to the Late Pliocene intensification of Northern Hemisphere glaciation?
- Did composition and cyclicity recorded in Weddell Sea sediments change during the Mid-Pleistocene Transition?
- What is the glacial-to-interglacial record of EAIS dynamics?
- What are the changing source signatures of glacially derived material, and can we infer phases of AIS instability or ice-stream flow switching?
- Was there a Filcher-Rnne Ice Shelf collapse during warmer-than-today 'super' interglacials (MIS 5, 11, 31)?
- Can the interhemispheric ice-sheet synchronicity hypothesis be sustained for stadial-to-interstadial changes and previous deglaciations?
- How large was the Weddell Sea sector of the AIS during glacial periods and was the size controlled by hysteresis in the AIS?
- Are decadal-scale glacial AIS dynamics documented from varves caused by solar forcing, atmosphere-ocean interactions, or a combination thereof?
- Can we reconstruct AIS mass loss and ocean-atmosphere history from Iceberg Alley since the Mid-Pliocene?

Non-standard measurements technology needed to achieve the proposed scientific objectives.

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
WS-01	-74.237, -27.2852	2411	400	0	400	This primary site is planned to drill into the southern levee ridge on the continental slope northeast of Crary Fan. It should provide the most complete high-resolution Plio-Pleistocene record deposited closest to the continental shelf, indicative for ice-sheet dynamics in the Weddell Sea sector of the EAIS since the Late Pliocene. Deposits contain seismic sequences WF3.12 to WF3.6. Expected age at bottom is ~3.4-3.6 Ma.
WS-02	-74.07299, -27.6947	2487	500	0	500	This primary site is planned to drill into the middle levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Plio-Pleistocene records in an intermediate distance to the shelf edge, indicative for ice-sheet and sea-level dynamics in the Weddell Sea

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-	-	-	-	-	-	part of the East Antarctic Ice Sheet.
WS-03B	-73.5011, -27.876	3270	1000	0	1000	This alternate site is planned to drill into the northern levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Mio-Pliocene records in a more distal position to the shelf edge, and indicative for ice-sheet dynamics in the Weddell Sea sector of the EAIS since the Miocene. Deposits contain seismic units WS-S5 to WS-S7 above reflector W5 (11-18 Ma).
WS-04B	-73.6602, -27.474	3025	1000	0	1000	This alternate site is planned to drill into the northern levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Mio-Pliocene records in a more distal position to the shelf edge, and indicative for ice-sheet dynamics in the Weddell Sea sector of the EAIS since the Miocene. Deposits contain seismic units WS-S5 to WS-S7 above reflector W5 (11-18 Ma).
WS-11B	-73.9480, -26.6830	2894	400	0	400	This alternate site is planned to drill into the southern levee ridge on the continental slope northeast of Crary Fan. It should provide a complete and high-resolution Plio-Pleistocene record deposited on the ridge closest to the continental shelf, indicative for ice-sheet dynamics in the Weddell Sea sector of the EAIS since the Late Pliocene. Deposits contain seismic sequences WF3.13 to WF3.9. Expected age at bottom is ~2.5-3 Ma.
WS-05	-71.350, -24.803	3456	200	0	200	This primary site is planned to drill into the central part of Polarstern Plateau. It should provide complete information on the Cenozoic paleoceanographic and glacial history of the Weddell Sea in a distal, low-sedimention area that should be undisturbed.
WS-17	-68.2074, -7.2212	3953	300	0	300	This primary site on Bungenstock Plateau is planned to drill contourites in the northeastern Weddell Sea outside the sea-ice zone to unravel the Miocene to Pleistocene ic-sheet historyof the eastern Weddell Sea sector of the EAIS at lower resolution since the Miocene. Deposits contain reflector W5 (11-18 Ma).
WS-18	-68.5727, -4.2432	3230	300	0	300	This alternate site near Bungenstock Plateau is planned to drill contourites in the northeastern Weddell Sea outside the sea-ice zone to unravel the Miocene to Pleistocene ic-sheet historyof the eastern Weddell Sea sector of the EAIS at lower resolution since the Miocene. Deposits contain reflector W5 (11-18 Ma).
WS-16	-70.8315, -14.5735	2426	300	0	300	This alternate site is planned to re-drill ODP Site 693 with nowadays methods and technology unravel the Miocene to Pleistocene ic-sheet historyof the

-	-	-	-	-	-	eastern Weddell Sea sector of the EAIS at lower resolution since the Miocene. Deposits contain seismic units WS-S5 to WS-S7 above reflector W5 (11-18 Ma).
WS-14B	-72.7099, -26.6402	3600	700	0	700	This alternate site is planned to drill the northern extension of the channel ridge systems to unravel the Miocene to Pleistocene ic-sheet historyof the eastern Weddell Sea sector of the EAIS at lower resolution since the Miocene. Deposits contain seismic units WS-S5 to WS-S7 above reflector W5 (11-18 Ma).
WS-19	-66.84715, -33.480	4653	300	0	300	This alternate site is planned to re-drill ODP Site 694 with nowadays methods and technology unravel the Miocene to Pleistocene ic-sheet historyof the eastern Weddell Sea sector of the EAIS at lower resolution since the Miocene. Deposits contain seismic units WS-S5 to WS-S7 above reflector W5 (11-18 Ma).
WS-13B	-73.6011, -29.0058	3180	1200	0	1200	This primary site is planned to drill into the northern levee ridge on the continental slope northeast of Crary Fan. It should provide high-resolution Mio-Pliocene records in a more distal position to the shelf edge, and indicative for ice-sheet dynamics in the Weddell Sea sector of the EAIS since the Miocene. Deposits contain seismic units WS-S5 to WS-S7 above reflector W5 (11-18 Ma).
SCO-01	-57.4333, -43.4500	3101	600	0	600	This alternate site should be drilled if the primary Weddell Sea sites are inaccessible. Site is on transit route from South America and provides high-resolution, Pliocene to Pleistocene record of AIS dynamics in Iceberg Alley, the major transport route for Antarctic icebergs (Weber et al., 2014), when exiting the Weddell Sea Embayment. Expected age at base is ~4 Ma.